ENGINEERING DESIGN

Description:	In Engineering Design, engineering scope, content and professional practices are presented through practical application. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and project-based learning. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course will maintain a focus on how engineers apply their creativity, resourcefulness, mathematical, scientific, and technical knowledge and skills in the creation or refinement of technological products/systems. A key approach will be the employment of a sophisticated, sequential, and iterative design and development process to solve authentic engineering tasks/problems using Project-based Learning. Students will be challenged to participate as members of engineering teams within a typical business organization. Independent and group work will be reflective of authentic engineering projects found in the design world. Student performance within this structure will be assessed in numerous and diverse ways. It is important to note that measurement of student performance will be reflective of actual professional engineering evaluative processes currently used in this career field. Both independent and collaborative work will be carefully analyzed as students perform within an authentic engineering enterprise environment. The following major topics or chapters will be included to organize instruction of appropriate standards and benchmarks and reflect contemporary engineering industry practices. Principles of Design Engineering Resources Engineering Design Process Project Management This course is a capstone or AP level course that will include mostly high school junior and seniors who do intend to continue their education in Sciences, technology, engineering, or mathematics (STEM) at the post-secondary level, especially a four-five year baccalaureate degree.
Pre-requisites	Successful completion of Algebra 2 or higher mathematics course Successful completion of Foundation of Technology course Successful completion of Technological Issues Successful completion of Advanced Design Applications or Advanced Technological Applications
Recommended Credits:	1
Recommended Grade Levels:	12th

Standard 1.0
Demonstrate leadership, citizenship, and teamwork skills required for success in the school, community and workplace through Technology Student Association.

Standard 2.0
Practice personal and occupation safety relating to engineering design.

Standard 3.0
Develop a knowledge and understanding of the Principles of Design

Standard 4.0
Develop a knowledge and understanding of the Core Concepts of Engineering Resources.

Standard 5.0
Develop a knowledge and understanding of the Engineering Design Process

Standard 6.0
Develop a knowledge and understanding of the Core Concepts of Project Management

STANDARD 1.0

Demonstrate leadership, citizenship, and teamwork skills required for success in the school, community and workplace through Technology Student Association.

LEARNING EXPECTATIONS

The student will be able to:

1.1 Exhibit positive leadership skills.
1.2 Participate in the Technology Student Association (TSA) as an integral part of classroom instruction.
1.3 Demonstrate the ability to work cooperatively with others in a professional setting.
1.4 Outline leadership skills and team building.
1.5 Identify personal, teamwork and leadership skills used in various occupations.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student should know and be able to:

1.1.1 Conduct a self-study of personal leadership and teamwork styles.
1.1.2 Identify and utilize the strengths of individuals to solve a problem as a team.
1.2.1 Explain the importance of the principles expressed in the TSA Motto and Creed.
1.2.2 Prepare a meeting agenda for a TSA monthly/weekly meeting.
1.3.1 Participate in and conduct meetings according to accepted rules of parliamentary procedure.
1.4.1 Participate in various TSA activities and/or competitive events.
1.5.1 Work with a team to develop, implement and evaluate the effectiveness of a community or school service project

SAMPLE PERFORMANCE TASKS

- Create a leadership inventory and use it to conduct a personal assessment.
- Participate in various TSA programs and/or competitive events.
- Evaluate an activity within the school, community, and/or workplace and project effects of the project.
- Implement an annual program of work.
- Prepare a meeting agenda for a TSA monthly/weekly meeting.
- Attend a professional organization meeting.
- Participate in a leadership conference for TSA.

INTEGRATION/LINKAGES

- International Technology Education Association – Center to Advance the Teaching of Technology and Science (ITEA-CATTS)
- Tech-Know Project Middle School Teacher's Guide A
- Tech-Know Project Middle School Teacher's Guide B
- Human Innovation Technology Series HITS
- Engineering Your Future Project Activities
- Technology Student Association Curriculum Resources Guide for Middle School and High School Events.

STANDARD 2.0
Safely use tools, materials, equipment and other technology resources.

LEARNING EXPECTATIONS

The student will be able to:
2.1 Successfully pass a test on general classroom, lab, and/or shop safety guidelines with 100% accuracy.
2.2 Successfully pass a test on the safe use of tools and equipment used in the lab and/or shop with 100% accuracy.
2.3 Successfully pass a test on the safety hazards that exist at home, school and in the workplace.
2.4 Using research relating to OSHA regulations conduct a safety inspection for a lab, school, or business.
2.5 List and explain the importance of safety guidelines for TSA competitive events.
2.6 Understand general laboratory safety rules and regulations when using tools, equipment and performing processes.
2.7 Understand safety, nomenclature and usage of all hand tools used in this course.
2.8 Understand and explain potential safety, chemical, electrical and fire safety hazards that exist in a Technology Engineering classroom and their school.
2.9 List all safety rules required when competing in specific TSA competitive events.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to:
2.1.1 Successfully pass a test on general classroom, lab, and/or shop safety guidelines with 100% accuracy.
2.2.1 Successfully pass a test on the safe use of tools and equipment used in the lab and/or shop with 100% accuracy.
2.3.1 Successfully pass a test on the safety hazards that exist at home, school and in the workplace.
2.4.1 Using research relating to OSHA regulations, conduct a safety inspection for a lab, school, or business.
2.5.1 List and explain the importance of safety guidelines for TSA competitive events.
2.6.1 Understand general laboratory safety rules and regulations when using tools, equipment and performing processes.
2.7.1 Understand safety, nomenclature and usage of all hand tools used in this course.
2.8.1 Understand and explain potential safety, chemical, electrical and fire safety hazards that exist in a Technology Engineering classroom and their school.
2.9.1 List all safety rules required when competing in specific TSA competitive events.

SAMPLE PERFORMANCE TASKS:

- Students successfully pass a written or oral test on fire safety.
- Students successfully pass a written test on all hand tools to be used in the laboratory.

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STANDARD 3.0
Develop a knowledge and understanding of the Principles of Design

LEARNING EXPECTATIONS

The student will be able to:

3.1 Understand the key principle of design, “human factors”, that impacts product design.
3.2 Understand the key principle of design, “environmental factors”, that impacts the design of major construction projects.
3.3 Understand the key principle of design, “industrial factors”, that impacts product design.
3.4 Understand design as a result of formal scientific research to achieve specific goals.
3.5 Enable students to describe, apply, and analyze a formal engineering design process with the context of authentic engineering design work.
3.6 Define, apply, and analyze a formal engineering design process within the context of authentic engineering design work.
3.7 Understand that designs are seldom presented in a clearly defined form and must be critically reviewed.
3.8 Analyze critical factors that lead to design improvements.
3.9 Analyze design requirements during a design development process and be able to make effective decisions for trade-offs to obtain the optimum solution.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to:

3.1.1 Define terms associated with human factors affecting design.
3.1.2 Identify ergonomic factors that must be addressed to facilitate human use.
3.1.3 Analyze a few every day devices and chart your observations and reactions using ergonomic features and ADA compliance requirements.
3.1.4 Describe and perform key measurements and calculations that must be considered during an ergonomic assessment.
3.1.5 Present information in a written form with supporting data and graphs.
3.2.1 Analyze engineering design failures in terms of environmental impacts.
3.2.2 Compare and contrast federal, state, and local environmental legislation impacting construction design.
3.2.3 Collect measurement data and graph body measurements in Assessment 1.1.3 for documentation.
3.3.1 Identify, define, and describe the IDSA – Industrial Designers Society of America critical goals impacting product design.
3.3.2 Conduct appropriate analysis of products using the IDSA – Industrial Designers Society of America
3.4.1 Define and describe comprehensive research techniques and tools used by scientists, designers, and engineers.
3.4.2 Apply actual research and experimentation processes used in engineering and science as part of a formal investigation.
3.4.3 Describe and apply the scientific method as part of an investigation.
3.5.1 Define, describe and analyze new product platforms, derivatives of existing products, incremental improvements to existing products, new products, and a profit margin concept.
3.5.2 Conduct an “industry-based” market analysis to minimize risk and improve profits.
3.6.1 Identify, describe, and apply the engineering process.
3.6.2 Define, describe, plan, and use required documentation in the design process.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to:

3.7.1 Design an ergonomic living environment in a residential home using an available CADD program or hand architectural drawing.
3.7.2 Compare several different designs of contemporary bikes and create a CADD drawing of your design.
3.7.3 Design and build a small scale model water treatment plant in subgroups or teams. critical goals.
3.8.1 Describe the three factors that can lead to design improvements – new knowledge, technological capability, and competing technologies.
3.9.1 Recognize, analyze, and generate design criteria, and design constraints.
3.9.2 Describe and analyze design efficiency.

PERFORMANCE TASKS:

- Students will work in small groups and complete Exploration – Unit 1 – Lesson 1, Pg.1.
- Students in groups will complete Explanation – Unit 1 – Lesson 1, 1-3, Pg. 1. Submit for grade.
- Compare several different designs of contemporary bikes and create CADD drawing showing the location of key components, such as, brakes, shifter, seat, pedals and available adjustments and range of adjustments for those controls. A spreadsheet should be generated comparing all models analyzed with the criteria for the comparison.
- Students will survey people who use computers. Divide the list into those who use a standard mouse, those who use the trackball mouse, and those who use an optical mouse. Establish criteria for the survey and have people respond as to their preference using the established criteria. Results are analyzed and charted in a spreadsheet for presentation to the class and further discussion related to ergonomic design for current use of pointing-device technologies for computers.
- Students will identify 20 people who ride bicycles. They will measure the length of their legs from hip joint to the bottom of the foot with shoes on. Now measure the height of their bicycle seats above the ground. Plot a histogram of the ratio of the seat height to leg length. Is there any obvious pattern? Is there any gender correlation? Students will present their findings.
- Students individually will read one of the following Case Studies and submit a report from the following: Dow Corning Corporation (Silicone Breast Implants), pages, 32-54; Volata River Project (Ghana electrical needs), pages 247-269; W.R. Grace and Co. and the Neemix Patent (Biopesticide product) pages 197-209.
- The class, working in sub groups, will design and build a model water treatment plant. This project should be an “entire class” initiative.
- Students work in small groups to analyze a few everyday devices and chart their observations and reactions using ergonomic features and ADA compliance requirements presented via a worksheet. Items are passed around to each group so that all students analyze the same devices (mobile phones, garden tools, skateboards, etc.).
- Students are organized into teams (of 2-3) for the purpose of researching the control of fire protection in materials, systems and fabrication operations. Example: The fires resulting from terrorist attacks on the World Trade Center twin tower in New York in 2001 was one of the more recent that supports improved designs for tall building with regard to fire protection. Students should investigate the most current standards for testing numerous and diverse environmental materials that are found in such structures.

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STANDARD 4.0
Develop a knowledge and understanding of the core concepts of Engineering Resources.

LEARNING EXPECTATIONS

The student will be able to:
4.1 Utilize technology transfer, across disciplines, and internationally.
4.2 Realize the value of protecting the patent process of inventions and innovations.
4.3 Use authentic engineering resources for performing critical mathematical calculations and apply scientific principles for an engineering problem.
4.4 Identify and define classifications of materials, unique characteristics of materials, and how materials are developed refined, and used in numerous technologies.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to:
4.1.1 Investigate, analyze, identify, and describe technology transfer methods among specific industries (medical, agricultural, power/energy, communication, transportation, manufacturing, construction).
4.1.2 Write clear step-by-step instructions for conducting investigations, operating something, or following a procedure.
4.1.3 Analyze and describe the U.S. government's role in technology transfer.
4.2.1 Identify and describe materials in diverse technologies appropriately.
4.2.2 Compare and contrast a wide variety of industrial materials accurately.
4.2.3 Select and use materials as part of a design solution.
4.3.1 Use scientific principles and perform scientific calculations to solve a design problem.
4.3.2 Identify and describe materials in diverse technologies appropriately.
4.3.3 Apply appropriate scientific principles to solve specific design problems.
4.4.1 Compare and contrast a wide variety of industrial materials accurately.
4.4.2 Describe the characteristics of natural, synthetic, and blended materials.
4.4.3 Identify, describe, and apply material testing techniques.

PERFORMANCE TASKS:

- Students use the "biomass generator designs" and models they created in Unit 1, Lesson 4. Each group functions as a technology transfer department within a biotechnical research company. Students apply what they have learned about how a technology transfer works and the formal steps required to facilitate a successful transfer of one technology to a new application or multiple applications of the same technology. In some cases, slight modifications may be necessary so that the design is optimized for the new application. A model and supporting design analysis showing "previous" application and the "new" application must be presented.
- Students write a brief description of what they already know about the following material classifications: natural, synthetic, and blended. This description should include clear statements, with appropriate visual images to help support their responses. The instructor "charts" descriptions and ideas so all can view them. A common set of ideas, statements, definitions or concepts should be identified under each major heading: natural, synthetic, and blended. This approach helps identify prior knowledge and address major misconceptions.

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STANDARD 5.0
Develop a knowledge and understanding of the Engineering Design Process

LEARNING EXPECTATIONS

The student will be able to:

5.1 Identify the personal characteristics that are valued and used in creativity, ingenuity, resourcefulness, and abstract thinking in design.

5.2 Define, describe, and apply design principles of flexibility, balance, function, and proportion for numerous and diverse designs.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to:

5.1.1 Demonstrate and refine creativity in all projects and design activities.
5.1.2 Identify the design problem to solve and decide whether or not to address it.
5.1.3 Synthesize engineering problems require clarification (customer needs and clear articulation).
5.2.1 Define, describe and apply the principle of balance, principle of function, and principle of proportion in product designs.
5.2.2 Understand the modeling concepts used in the development of prototypes and virtual simulations.
5.2.3 Communicate results using verbal, graphic, quantitative, virtual, written, and modeled solutions.
5.2.4 Demonstrate ability to design a problem solving program using programming languages.
5.2.5 Explain why engineers use precise drawing methods.
5.2.6 Identify important features of technical drawing.
5.2.7 Recognize and be able to draw orthographic, oblique, isometric and perspective drawings.
5.2.8 Dimension a technical drawing.
5.2.9 Build a Scale model or Prototype, identify tools and safety rules for building prototypes, and test and analyze your final product.
5.2.10 Research and apply the knowledge of mathematics, science, and engineering technology.
5.2.11 Read and extract information from manuals, journals, and other discipline related literature.
5.2.12 Design and conduct experiments, as well as analyze and interpret collected data.
5.2.13 Identify, formulate, and solve engineering technology-based problems.
5.2.14 Create or fabricate a system, subsystem, component, or process to meet specified needs of an engineering design problem.

STANDARD 6.0
Develop a knowledge and understanding of the core concepts of Project Management

LEARNING EXPECTATIONS

The student will be able to:
6.1 Understand and apply project management functions for engineering design work.
6.2 Recognize, investigate, describe, analyze, and apply quality assurance process.
6.3 Generate a quality product, system, or service using the 12-step engineering design process.
6.4 Use technology and present engineering findings in project management.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student should know and be able to
61.1 Identify, describe, and apply project planning, organization structures, scheduling techniques, control methods, resource allocation methods, and describe trends in project management techniques.
6.1.3 Use software application to prepare documents and spreadsheets.
6.1.4 Create multi-media presentation to clearly define a design problem.
6.1.5 Identify, describe and apply principles of project management.
6.2.1 Identify and describe individuals and their contribution leading to contemporary quality assurance methods.
6.2.2 Identify and describe significant historical milestones in project management.
6.2.3 Present information in appropriate management formats.
6.2.4 Identify and describe significant individuals and their contributions leading to contemporary quality assurance methods.
6.3.1 Apply the 12-step engineering design process in the development of a product or system.
6.3.2 Apply Total Quality Assurance strategies for all planning, communications, and manufacturing as part of project management.
6.3.3 Apply quality assurance for the use of all tools, machines, materials, and processes during the manufacture of a product.
6.4.1 Develop skills in problem solving by using the computer effectively for engineering technology applications.
6.4.2 Send and receive internal and external E-Mail messages.
6.4.4 Identify and name the basic components of a personal computer.
6.4.5 Produce a “word-processed” document resume.
6.4.6 Print a drawing from a CAD program in the required format.
6.4.7 Design and build a spreadsheet to contain the engineering data needed to solve an engineering problem.

PERFORMANCE TASKS:

- Students will work in small groups and complete Engagement – Unit 4 –Lesson 1, 1-3, Pgs.5-6.
- Students will investigate the concept of Web-Based Enabler for engineering project management. Students will use The table in Student Resource 4.1.15 and follow all directions in Unit, Lesson 1 Engagement.
- Students will prepare a detailed report describing findings from an investigation of PERT and “Gantt charts (five elements required).
- Students will Complete Evaluation – Unit 4, Lesson 1, 1-24, Pgs. 13-14. The student assessment sheets are located in the curriculum under (Assessment Instrument 4.1.1-4.1.24).
- The final 6 to 9 weeks of this course is the “practicum experience, which provides the opportunity for them to clearly demonstrate their knowledge and skill for planning, organizing, and controlling an engineering design process for the development of an effective solution to an authentic problem.

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